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Design, Simulation & Fabrication of 5G Antenna using Multiband Micro Strip Patch Antenna

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Abstract: This article describes the construction of a single patch antenna array for 5G applications with frequency of 26 GHz. A rectangular patch antenna built on the FR-4 substrate that has been simulated and tuned using widely available electromagnetic simulation tools is the centre piece of this configuration.

Keywords: 5G, millimetre wave, patch antennas, antenna array and corporate feed.

I. INTRODUCTION

The micro strip based patch antenna is also called as printed antenna because the radiating element is printed on the front side of the substrate and the ground on the rear Copper, gold, and silver are common conducting elements used in the radiating element and the ground. The size and shape of the radiating element may change depending on how often it is used.

Micro strip patch antennas have been used in a variety of disciplines, including RFID, GPS, V2V communication, Satellite communication, Radar, and Remote sensing. However, one of the significant downsides of micro strip patch antennas is dielectric and surface wave losses. The micro strip patch antenna is able to achieve narrow bandwidth and lower strength due to this loss. Various strategies such as feeding method, meandering, metal materials, and EBG are used to solve the a for mentioned shortcomings.

The micro strip antenna's low cost and low profile made it more useful and compatible in MMIC fabrication. A metal material is a man-made material that has negative permittivity and permeability, This includes a micro strip patch antenna to improve gain, bandwidth, and other important factors Changing the patch shapes has been used in many studies to get a higher bandwidth. However, with the help of array arrangement, the gain can be enhanced. The suggested antenna’s design is a basic micro strip patch antenna operating at 26GHz.

II. LITERATURE SURVEY

A. Millimetre-wave 5G Antennas for Smartphones: Overview and Experimental Demonstration.

Wonbin Hong et al [1], this study gives an overview of Millimetre-Wave 5G mobile antennas. This paper discusses design considerations and solutions for integrating Millimetre-Wave horns that are divided into sections and have beam-changing capabilities. Two types of antennas with separated segments having horizontal and vertical duplicates are developed, fabricated, and measured at a frequency of 60 GHz in this study. After that, the antennas are joined with another 60 GHz RF and digital construction to create Millimetre-Wave antenna modules that may be integrated and used in fully working handsets under the right conditions. This research looks at the design considerations for a Millimetre-Wave 5G mobile control system. Furthermore, the author presented a miniature 60 GHz radio with integrated components that are compatible with all 60 GHz radio formats and are housed inside a fully functional mobile handset. Divided topology introduces two paragraphs that can be rearranged in real time to adapt to a new channel environment.

B. Design of Massive MIMO for 5G 28 GHZ.

Tito Yuwono1 et al [2], the antenna designs shown in this study support a few of the requirements listed below. The type of antenna used in this paper is a 10x10 member Massive MIMO patch antenna. The performance of the huge MIMO antenna is outstanding, and it matches the criteria. The gain is 27.4 dB, the S-parameter ratio is 14.29 dB, the median VSWR is 1.43, and the S-parameter ratio is 14.29 dB. 450 MHz is the usual bandwidth. As a result, the antenna described in this work is appropriate for 5G. A GBit / s rating is required for these applications. The solution for identifying GBit/s millimetre wave measurements. It does, however, contribute to bigger losses, necessitating higher earnings. Similar antennas with many antennas are high-profit options. As a result, a 5G member's frequency is millimetre wave. Meanwhile, 28GHz, 39GHz, and 60GHz were the most popular frequencies. Because the majority of millimetre-wave cell structures are microcell and pico-cell, millimetre-wave communication requires both high and low bandwidth. For gigabit connection, video, the Internet of Things (IoT), and virtual reality are the three sorts of markets that are driving 5G. A millimetre-wave frequency range is necessary to detect this. Due to greater loss and lower radiation efficiency, the method demonstrated in this study necessitates advanced engineering.

C. Antenna Design for 5G Communications.

P. W. Futter et al [3], this study discusses the difficulty of developing a 5G communication antenna that operates in the 26 GHz range. For starters, a mobile 8-bit wide 8-component antenna is designed. The proposed antenna performance in this paper comprises gain, assembly, and beam direction. In this study work, factors relating to the antenna assembly's flow function are also explored. In addition, the efficiency of the base station antenna is described in this study, and the performance is compared to the same members' adjustment. Due to the higher frequency losses that occur during these times, high-gain antennas at low-voltage stations and terminals are required to sustain the connection to the millimetre wavelength band, according to this article. While multi-element antenna chemical designs can do this, it comes at the cost of increased design complexity, lower beam width, and the need for high-quality supply circuits. By doing well and completing analysis, this study demonstrates that imitating will play a vital part in creating these novel antenna designs.

D. mm Wave Novel Multiband Micro strip Patch Antenna Design for 5G Communication.

ZeeshanLodro et al [4], the millimetre-Wave multiband patch antenna design for 5G communication is described in this research. With a high bandwidth of 5.5 GHz and 8.67 GHz, the 5G millimetre-wave antenna repeats the 37 GHz and 54 GHz bands. This is made of low-tech materials and has features like low weight, low cost, low profile, high gain, and efficiency. The CST MWS simulation programme was used to create this 5G antenna. It is 7.2x5.0x0.787 mm3 and has a tiny form factor. The 5G multiband antenna has a gain of 5 dBi and 6 dBi, respectively, which is suitable. The antenna connects to smart devices effortlessly and can be used for 5G connectivity. High data transfer speeds are required for high-definition videos and high-volume traffic nowadays. The full maximum bandwidth of the GHz microwave frequency spectrum is insufficient to meet the needs. As a result, the fifth generation 5G wireless connection is proposed to address the demand for high data rates. Millimetre-wave (30-300 GHz) is proposed for 5G as it is not used and can provide quite large bandwidth. Millimetre-Wave is an integral part of fifth generation (5G) communications, due to their significant contribution to mobile communication services and multi-giga bit communication services.

III.METHODOLOGY

A. Single patch Antenna

The single patch antenna is the suggested antenna's basic design at 26 GHz. It's a basic rectangular micro strip feed patch antenna with a quarter-wave transformer feed line and a small rectangular nickel bar on the edge. The complete construction is built on a FR4 substrate, with the radiating element on one end and full ground on the other. The substrate has a height of 1.6 mm, a width of 13.144 mm, and a length of 11.367 mm. The radiating element's length and width are 1.965mm and 3.509mm, respectively, with a thickness of 0.035 mm. The suggested antenna is fed through a micro strip line and uses the fr4 (r = 4.4) material as a substrate, which is more efficient at high frequencies than other substrates.

The antenna design entails obtaining a number of parameters, including the operating frequency (f = 26GHz), the appropriate material with its dielectric constant for the substrate (r), and the thickness of the substrate, which will allow us to calculate the patch dimensions using the equations below.

1) *The antenna's width can be estimated using the formula:*

$$W=\frac{C}{2f}\sqrt{\frac{2}{\varepsilon_r+1}}=\frac{\lambda}{2}\sqrt{\frac{2}{\varepsilon_r+1}}$$

And the length with:

$$L=L_{eff}-2\Delta L=\frac{C}{2f\sqrt{\varepsilon_{eff}}}-2\Delta L$$

Using:

$$\Delta L=0.412\frac{(\varepsilon_{eff}+0.3)(\frac{W}{H}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{H}+0.8)}$$

And:

$$\varepsilon_{eff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r+1}{2}(1+12\frac{H}{W})^{-\frac{1}{2}}$$

2) *For Feed Line*

$WF = (377/zo\sqrt{er}.\ -2)\ h$

Where:

- W = width of the patch antenna.
- L = length of the patch antenna.
- f = resonance frequency.
- c = speed of light.
- εr = dielectric constant of the substrate.
- ΔL = length extension.
- H = thickness of the substrate
- $\varepsilon ef\ f$ = effective dielectric constant of the substrate
- Zo =impedance
- Wf= width of the feed

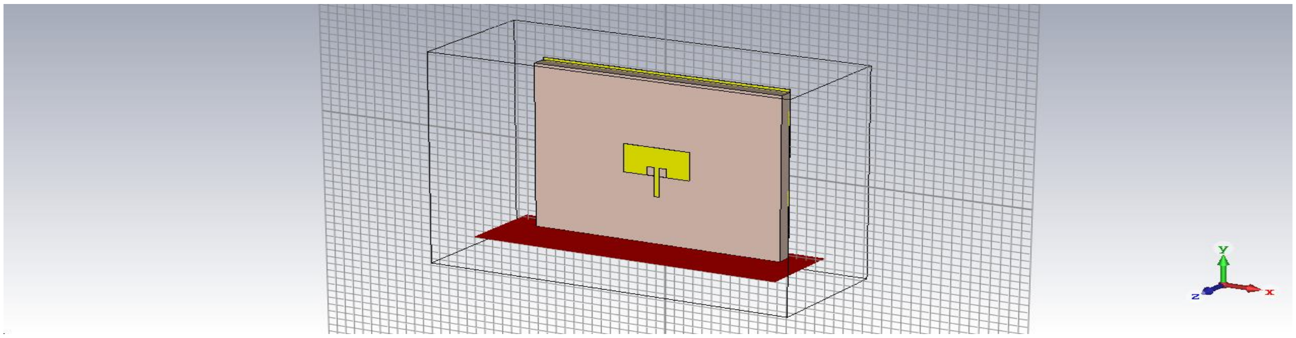


Figure 1: Design of 26hgz patch antenna.

3) *Parameters of Single Patch Antenna*

Parameters	Values (In mm)
Length Substrate	11.36
Width Substrate	13.144
Patch length	1.965
Patch width	3.509
Feed line length	4.8
Feed line width	1
Ground length	11.731
Ground width	13.144
Substrate Height	1.6
Patch Height	0.035

Table 1: Parameters of Single Patch Antenna

B. 1x2 Antenna

The single patch antenna is used as the array element for the 1x2 antenna array. The size of the 1x2 antenna array is twice that of a single patch antenna. The suggested 1x2 antenna array operates at the same frequency as a single patch antenna, but with a higher gain and return loss value.

An antenna array with a 1x2 element arrangement generated from a previously generated patch. A uniform opening distribution was chosen for the design, which implies that the power is divided evenly in each element.

Figure 1: shows the antenna, which was intended at a frequency of 26 GHz, and the quarter wave transformer method of coupling the patch's impedance to the transmission line a uniform opening distribution was chosen for the design, which means that the power is divided evenly in each element. For a 100 Ohm input line, this means that connecting lines for 70.7 ohm obtaining output lines of 50 Ohm.

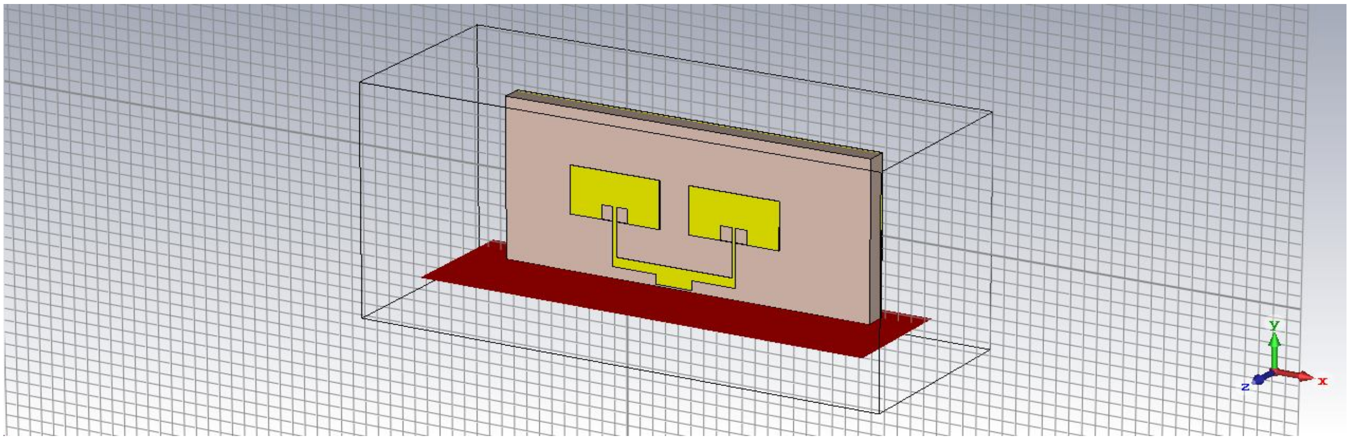


Figure 2: 1x2 array antenna

IV. RESULTS

A. Single Antenna

1) S Parameter

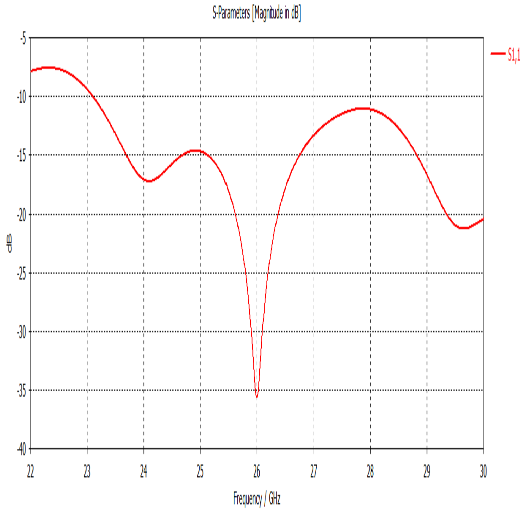


Figure3: Return Loss plot of antenna

Figure 3 shows the proposed antenna return loss -35.691dB plot is presented which clearly shows that the designed structure has an operating band from 23 GHz to 28 GHz with resonance at 26 GHz.

2) VSWR(Voltage Standing Wave Ratio)

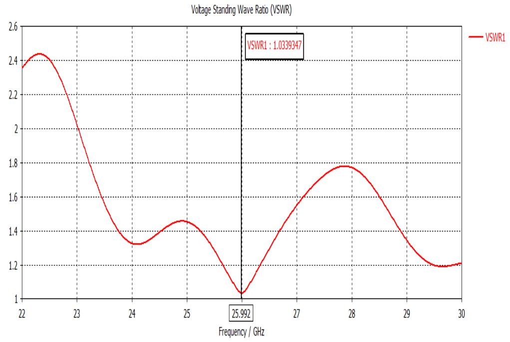


Figure 4: VSWR plot of the antenna

Figure 4 shows the antenna's VSWR plot, which shows that the VSWR is less than 2 in the operational band. And the VSWR at 26GHz is 1.003, which indicates that the antenna has great impedance coupling.

3) Far Field

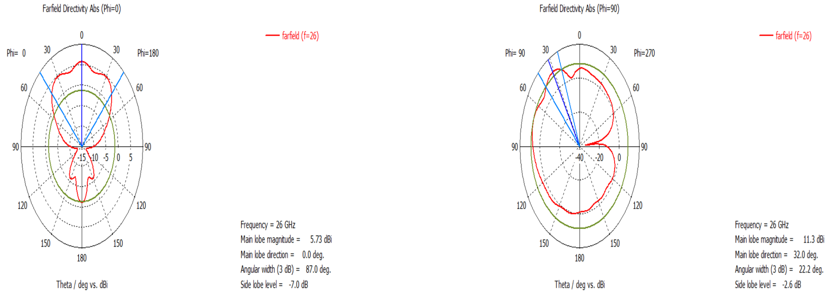
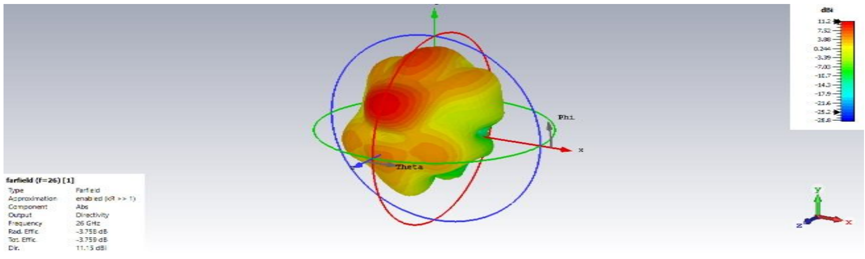


Figure 5: Antenna Radiation Pattern E plane and H plane

In Figure 5, The E and H planes are two different types of planes. The suggested single patch antenna radiation pattern is illustrated, which clearly demonstrates that it has an omnidirectional pattern. In E plane at 26 GHz, the radiation pattern in the YZ plane. The major lobe magnitude is 11.3 decibels, the main lobe direction is 32 decibels, the angular breadth (3 decibels) is 22.2 decibels, and the side lobe level is -2.6 decibels.

4) Far Field 3d View



farfield (f=26) [1]
Type Farfield
Approximation enabled (kR >> 1)
Component Abs
Output Directivity
Frequency 26 GHz
Rad. Effic -3.758 dB
Tot. Effic -3.759 dB
Dir. 11.15 dBi

Figure 6: 3D (Directivity) Radiation pattern of Antenna

In Figure6, The 3D directivity radiation pattern is shown, and it can be seen that the highest radiation is parallel to the antenna axis. The gain of the proposed antenna is plotted against frequency, and the gain is found to be greater than 10dBi.

The software simulator (Fig. 5) can be used to generate 3D and 2D radiation patterns. These graphs demonstrate that the greatest gain achieved in the radiation direction, z axis, is 11.15dB, which is a decent number for a tiny patch antenna. And 3D At 26 GHz, the radiation pattern of a single patch antenna in the YZ plane shows a realised gain of 10.31 dB, a radiation efficiency of -3.2958 dB, and a total efficiency of -3.759 dB.

B. 1x2 Antenna

1) S Parameter

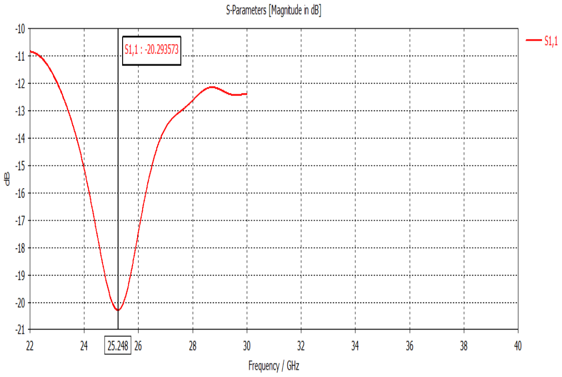


Figure 7: Return Loss plot of array antenna

The transmission and reflection coefficient S characteristics are displayed against the operation frequency. The simulated maximum return loss value is roughly -20.276dB, assuming a -10 dB threshold as shown in the graph.

2) VSWR(Voltage Standing Wave Ratio)

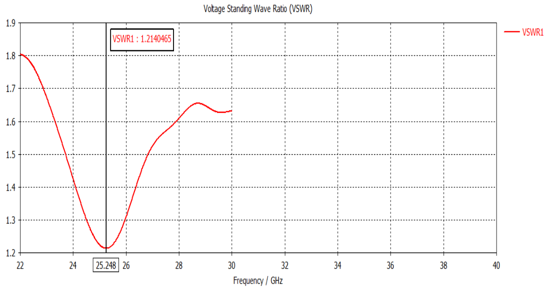
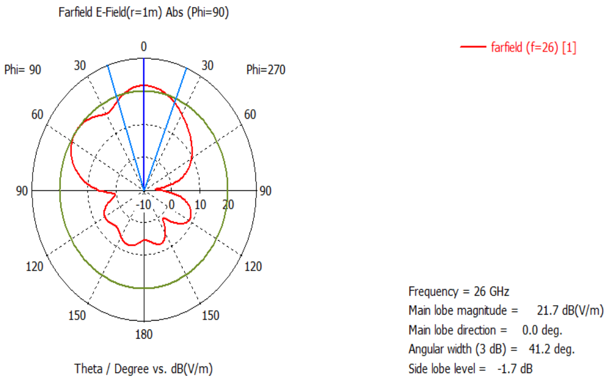


Figure 8: VSWR plot of the array antenna

In figure 8, the VSWR plot is shown, and we can see that the VSWR value in the operating band is less than 2. And the VSWR at 26GHz is 1.214, which indicates that the antenna has great impedance coupling.

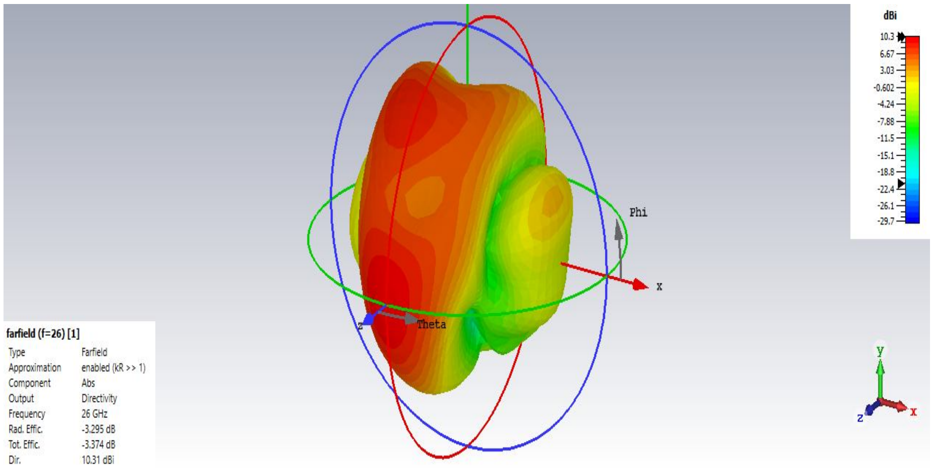
3) Far field



Figur 9: Array Antenna Radiation Pattern E plane and H plane

Figure 9, The E and H planes are two different types of planes. The suggested antenna array antenna's radiation pattern is presented, demonstrating that it possesses an omnidirectional pattern. YZ plane radiation pattern at 26 GHz. The main lobe magnitude is 21.7dB, the angular breadth (3dB) is 41.2 dB, and the side lobe level is -1.7 dB.

4) *Far Field 3D View*



farfield (f=26) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	26 GHz
Rad. Effic.	-3.295 dB
Tot. Effic.	-3.374 dB
Dir.	10.31 dBi

Figure 10: 3D (Directivity) radiation pattern of the antenna B

In Figure 10, 3D radiation pattern of the proposed 1x2 antenna array is shown. Because the spacing between the two antenna elements is chosen to be half of the resonating wavelength, there is very little mutual coupling between them.

The software simulator Fig.9 can be used to generate 3D and 2D radiation patterns. These graphs demonstrate that the greatest gain achieved in the radiation direction, z axis, is 10.31dB, which is a decent number for a tiny patch antenna.

3D At 26 GHz, the radiation pattern of a single patch antenna in the YZ plane shows a realised gain of 10.31dB, a radiation efficiency of -3.295 dB, and a total efficiency of -3.374 dB.

The antenna was made as illustrated in Fig. 8 utilizing a FR4 epoxy substrate in an electronic board prototype machine to compare it to a local denomination coin. However, due to a lack of technological equipment capable of working at 26 GHz, the results could not be verified. In the future, the results will be validated by employing a virtual environment and scaling the antenna to a lower operation frequency, which may allow measurement findings to be obtained.

Antenna type	Resonant Frequency(GHz)	Return loss(dB)	Bandwidth (GHz)	VSWR	Gain (dB)
Single patch antenna	26	-35.492	23-28	1.0031	11.15
Array antenna(Array 1x2)	25.248	-20.276	22-28	1.214	10.31

Table 2: comparing the Parameter of Single patch Antenna and 1x2Antenna (Values in mm)

C. *Comparison*

The results of Comparison between existing papers with similar resonance frequency at 26GHz)

This work mentioned in below References	Antenna type	Resonant Frequency(GHz)	Return loss(dB)	Bandwidth (GHz)	VSWR	Gain (dB)
[5]	Single patch Antenna	26	-35.492	23-28	1.0031	11.15
[6]	Patch Antenna at Ka band	26.87	-17.78	30.47-35	1.29	6.76
[7]	Micro strip Patch Antenna Using Plastic Deformation Magnetic Actuation	25.6	-34.24	25.62-28	~1	9.86
[8]	Design and Implementation of Micro strip Patch Antenna for 5G applications	26	-33.4	24.7-27.8	1.04	10
[9]	Ka-Band(26 GHz) Circularly Polarized 2x2 Micro strip Patch Sub-Array with Compact Feed	26.3	-35	24-27	1.02	9

Table 3: The results of Comparison between existing papers with similar resonance frequency at 26GHz)

V. CONCLUSION

A single element and a 1x2 array of patch antennas are proposed for future 5G applications in this article. It's made out of a single rectangular patch and uses a corporate feed network to distribute power evenly to each element. The suggested matrix achieves a bandwidth higher than, allowing for a high data transmission rate. We also acquired a gain of roughly 11dB, which will mitigate the challenges caused by propagation losses in the millimetre range. These parameters indicate our matrix's high performance at 26GHz, making this configuration suitable for 5G applications. In future study, we will look into ways to increase bandwidth and integrate phase shifters to accomplish electronic beam scanning or steering for mobile devices. The antenna can be included into devices when space is a critical consideration. Future 5G wireless devices will be able to utilise the planned antenna. This research could also help with millimetre-wave channel modelling, which is a hot topic in 5G system evaluation right now.

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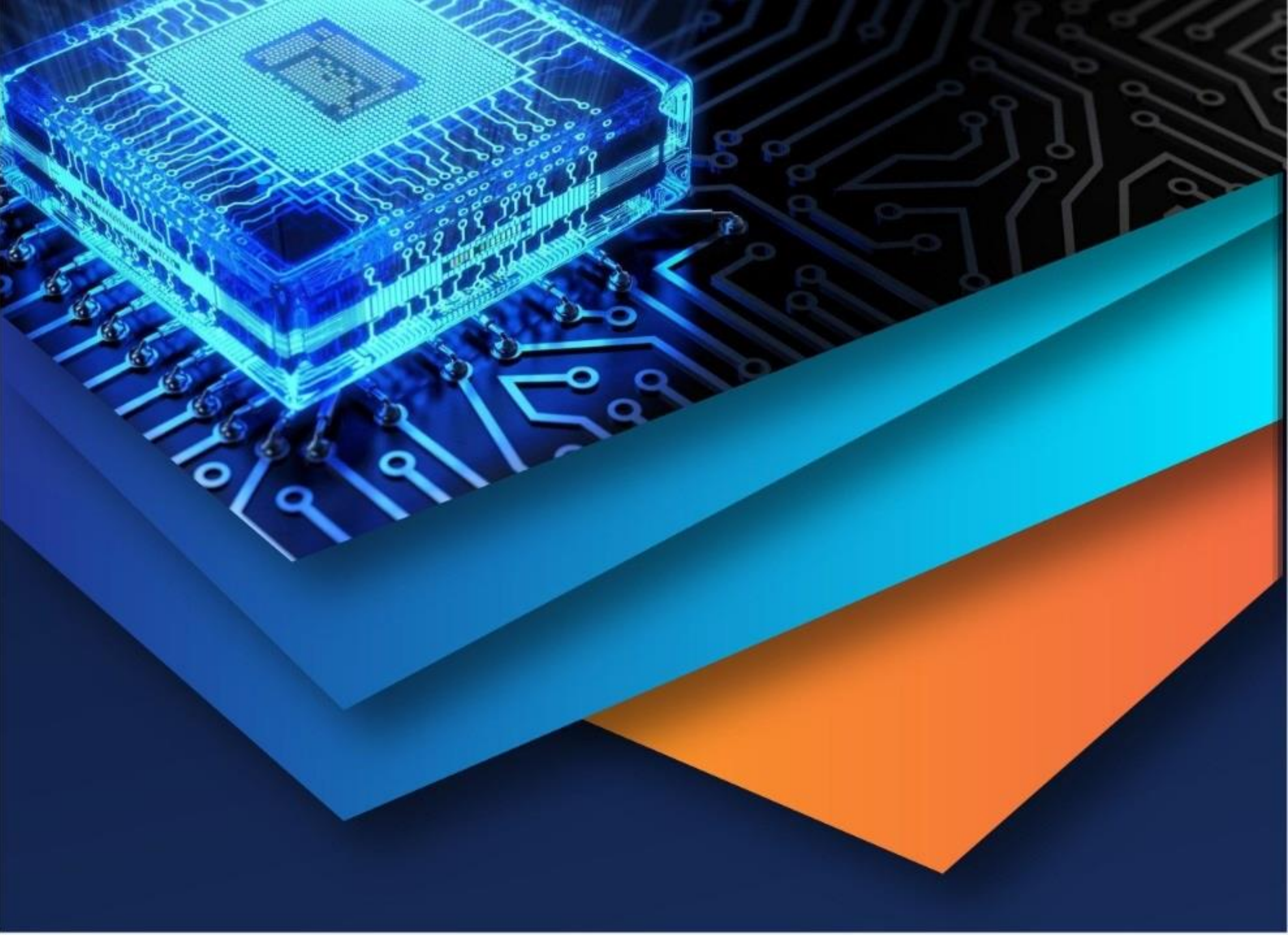

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